Fundamental research on nutrition and feeding practice of modern highly prolific lactating sows

现代高产哺乳母猪的营养与饲喂实践基础研究

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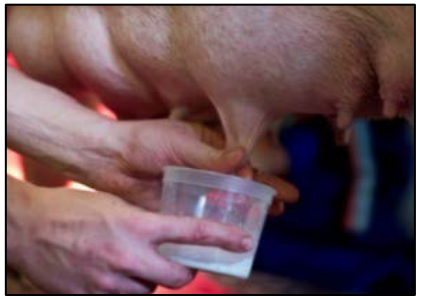
AU AARHUS UNIVERSITY

Agenda议程

- Lysine and energy requirements during transition and lactation
  过渡期和哺乳期间的赖氨酸和能量需求
- Farrowing分娩
- Colostrum初乳
- Milk yield, mobilization and feed efficiency产奶量、动员量和饲料效率
- Two component feeding双组份喂养
- Multicatheterised sows多瘘管母猪
- Feeding in practice在实践中喂养



What makes high-prolific sows special?

高产母猪有什么特别之处

1. Engine R&D发动机研制
2. Fuel R&D燃料的研发
3. Great team spirit伟大的团队精神

1. Genetics遗传学
2. Nutrition营养学

(Feeding system is a barriere)

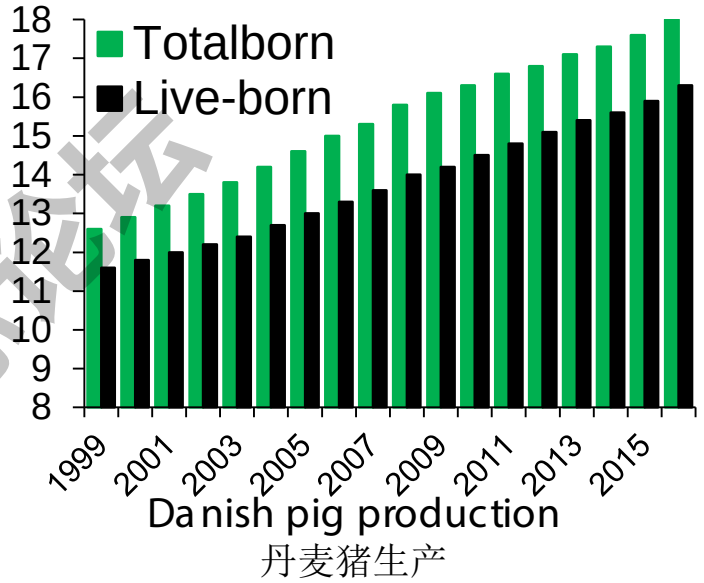
喂料系统是个障碍

3. Herd management畜群管理

Genetic selection for high prolificacy

高繁殖力的遗传选择

Litter size ↑产仔数



⇒ **Challenges productivity / physiology**

对生产力/ 生理学产生的挑战

1. **Farrowing length**产程
2. **Colostrum yield**初乳产量
3. **Milk yield**产奶量

Can we improve these traits by improving nutrition of prolific sows?

我们能通过改善高产母猪的营养来改善这些指标吗

Daily requirement of energy (MJ ME/ d)能源日需求量（MJ ME/ D）

Heat increment (Efficiencies < 100%)热增量（效率＜100%）

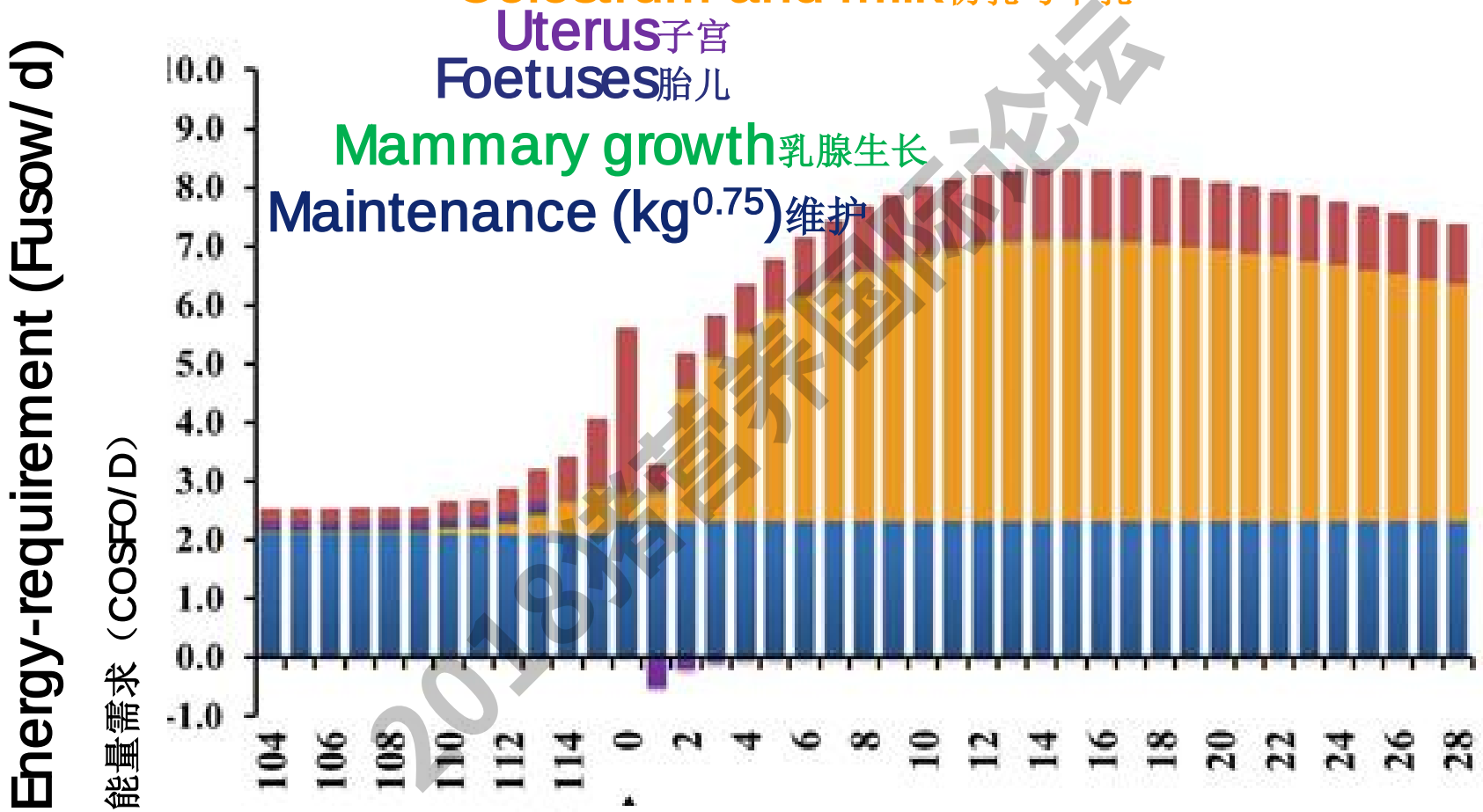
Colostrum and milk初乳与牛乳

Uterus子宫

Foetuses胎儿

Mammary growth乳腺生长

Maintenance ($kg^{0.75}$)维护



Gestation妊娠期　　Farrowing产仔　　Lactation哺乳期

(Feyera & Theil, 2017)

Daily requirement of lysine (g SID/ d)赖氨酸日需求量（G SID/ D）

Additional lysine (Efficiency < 100%)额外赖氨酸（效率＜100%）

Colostrum and milk初乳与牛奶

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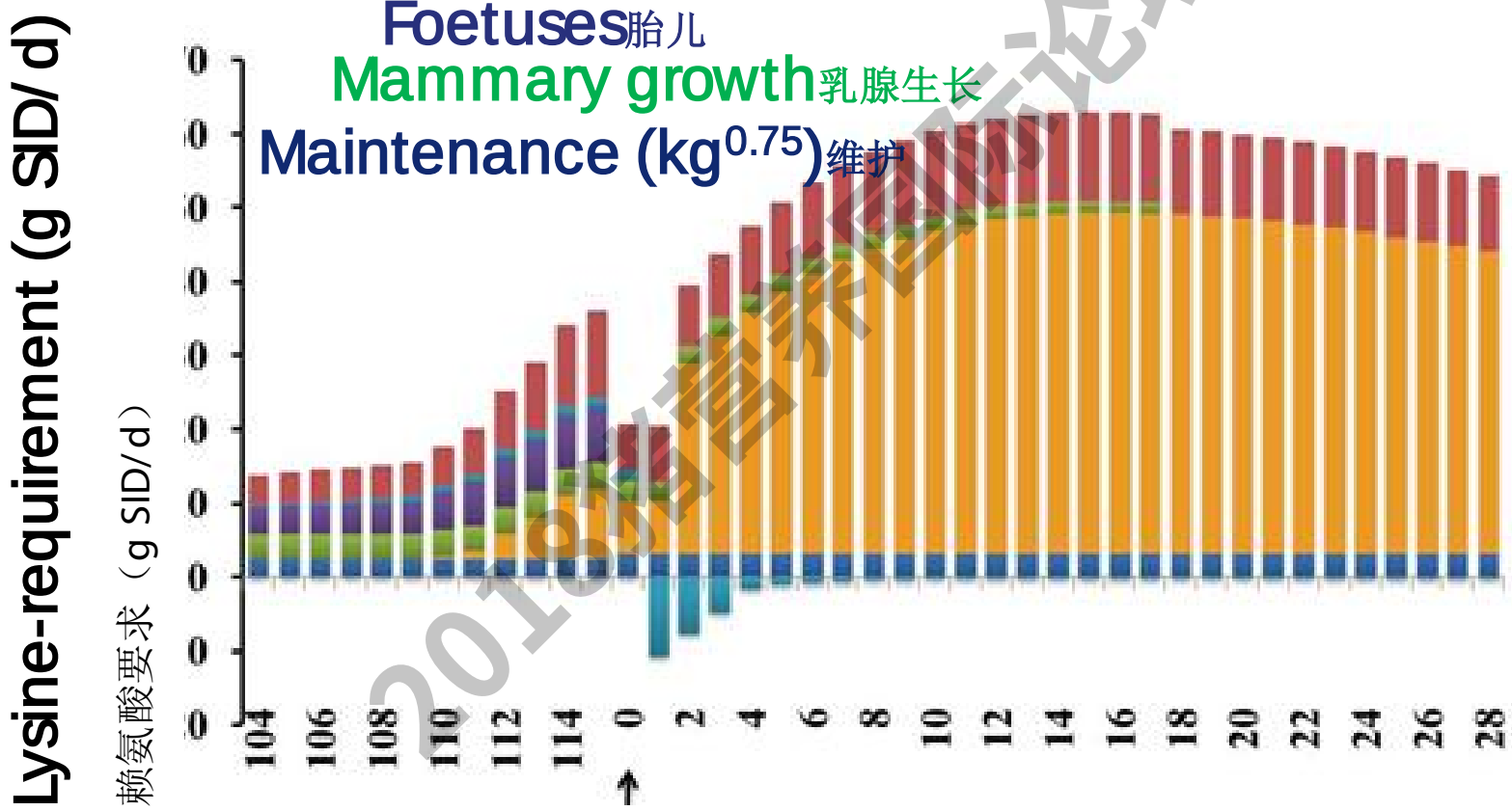


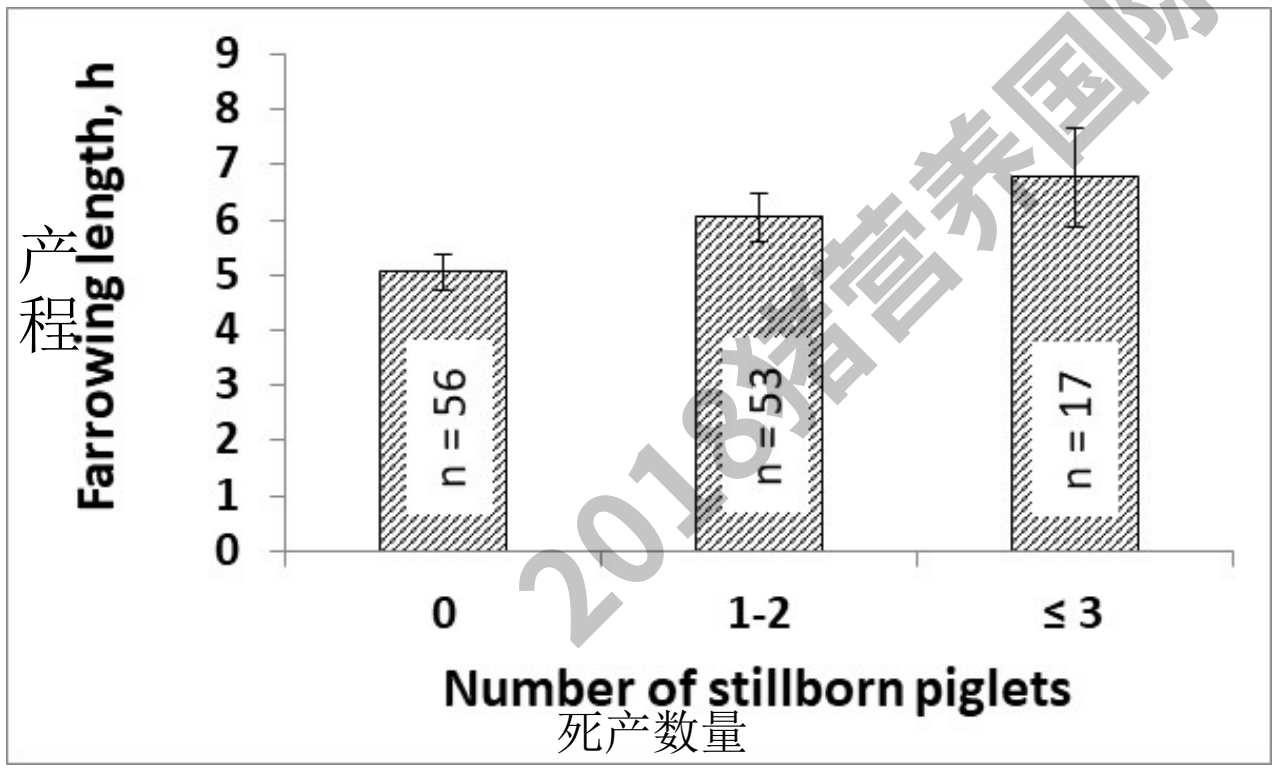
Gestation妊娠期　Farrowing产仔　Lactation哺乳期

(Feyera & Theil, 2017)

Does sow nutrition play a role for the farrowing process?
母猪营养是否会对产仔过程起作用？

Farrowing time < ------> number of stillborn piglets

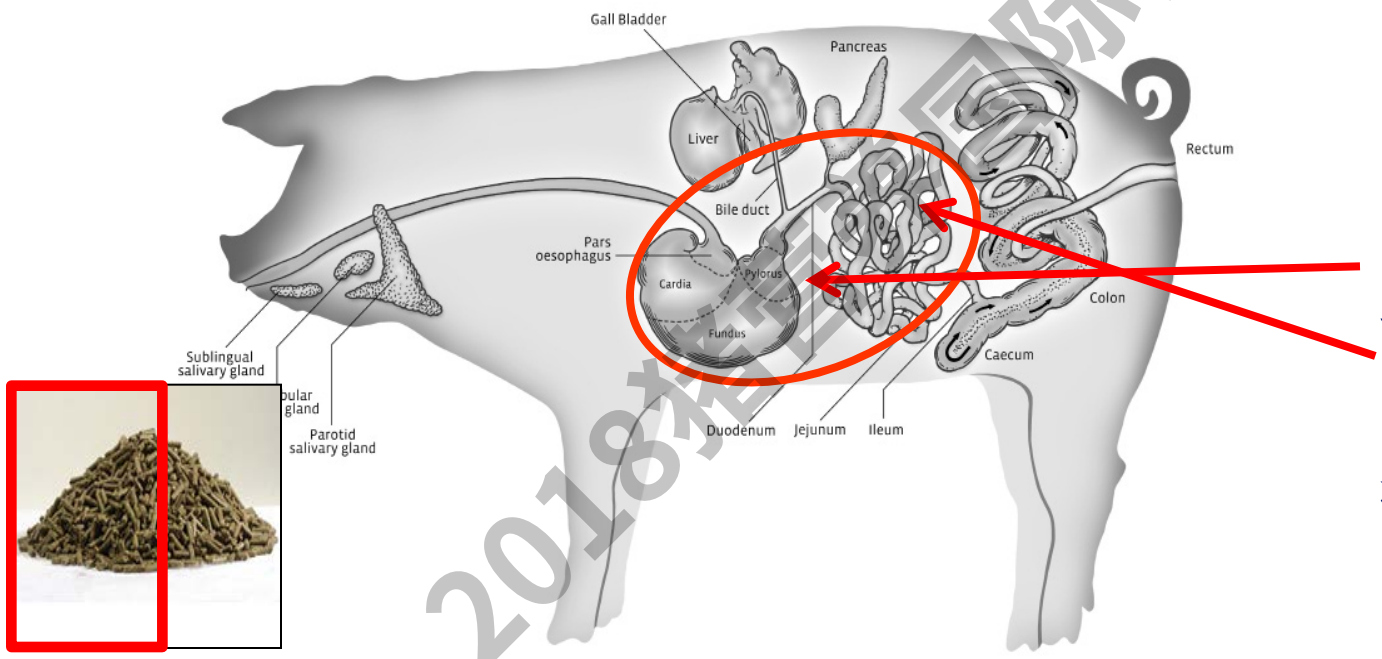
分娩时间<------>死产仔猪数量



Theil (2015)

Energy uptake from the GI-tract

胃肠道能量摄入



Net energy

净能量

uptake from

吸收来自

Lactate (10%)

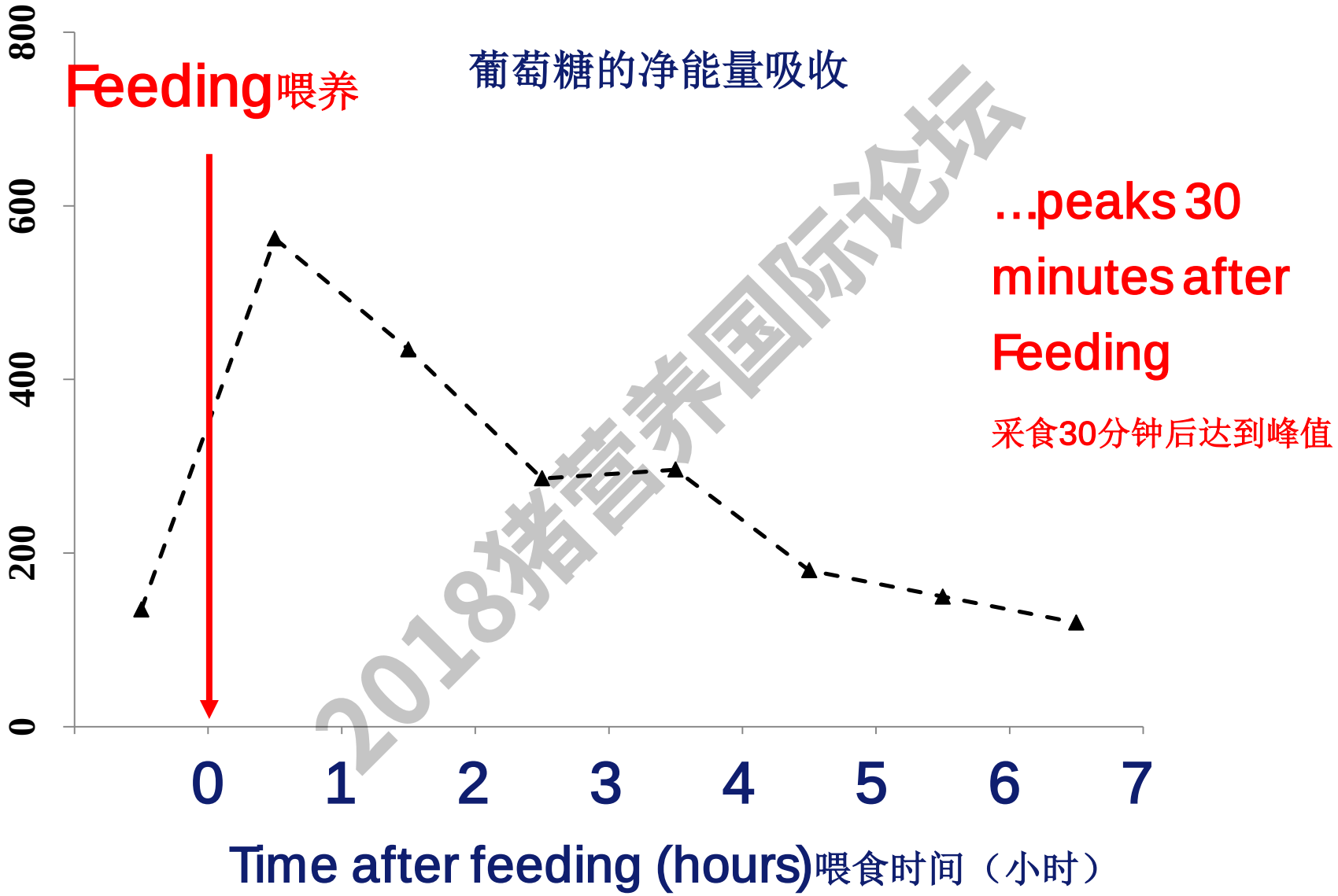
乳酸（10%）

Glucose

葡萄糖

Starch contribute with ~60% of ME淀粉占ME的约60%

Net energy uptake from glucose



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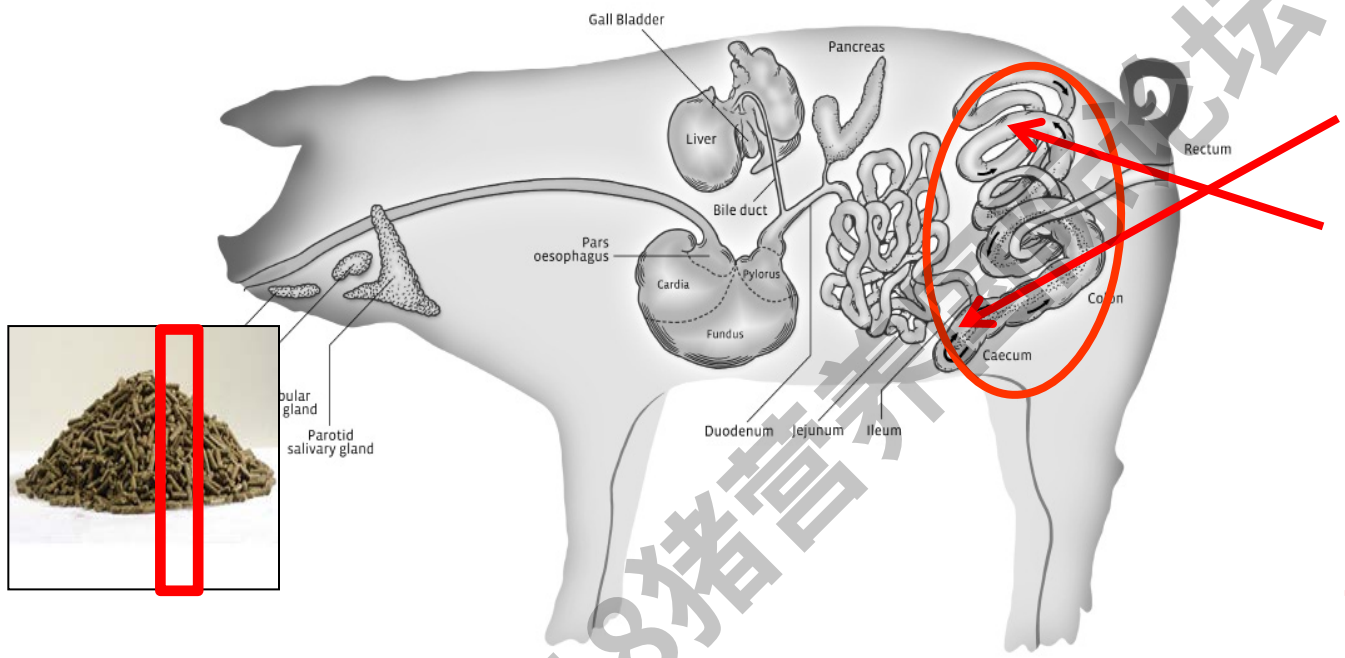


Fibre

Uptake from caecum and colon纤维在盲肠和结肠被利用

..is constant for 24 hours! 持续24小时

(Serena et al., 2009)

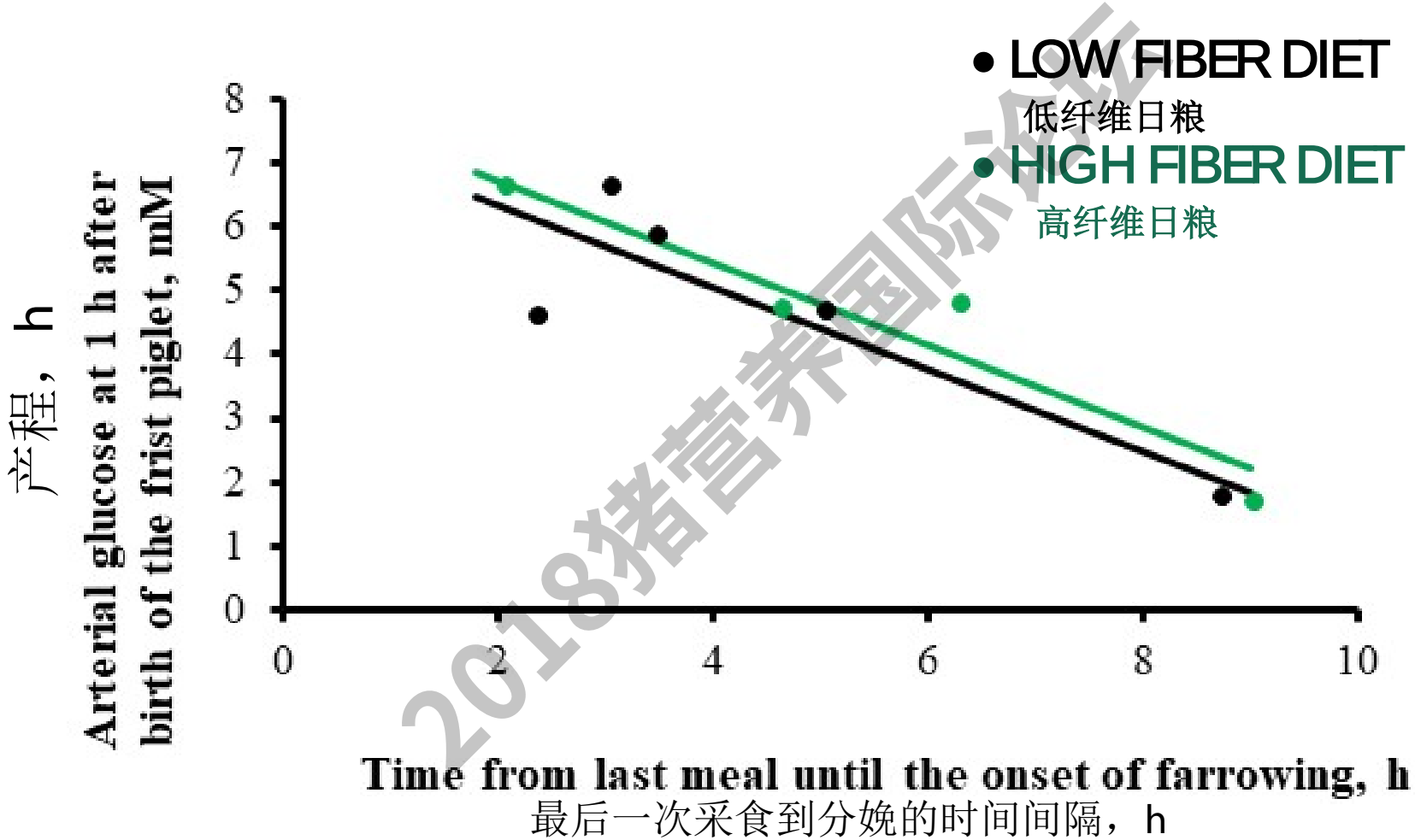
17%dietary fibre contribute with ~10%of ME17%的膳食纤维约10%的代谢能

High dietary fibre may contribute with ~30%of ME高膳食纤维可能贡献30%的代谢能

Fibre is a GREAT substrate to ensure high energy status during farrowing ...where feed intake is prevented

纤维是分娩过程中无法采食饲料情况下保证高能量状态的很好原料

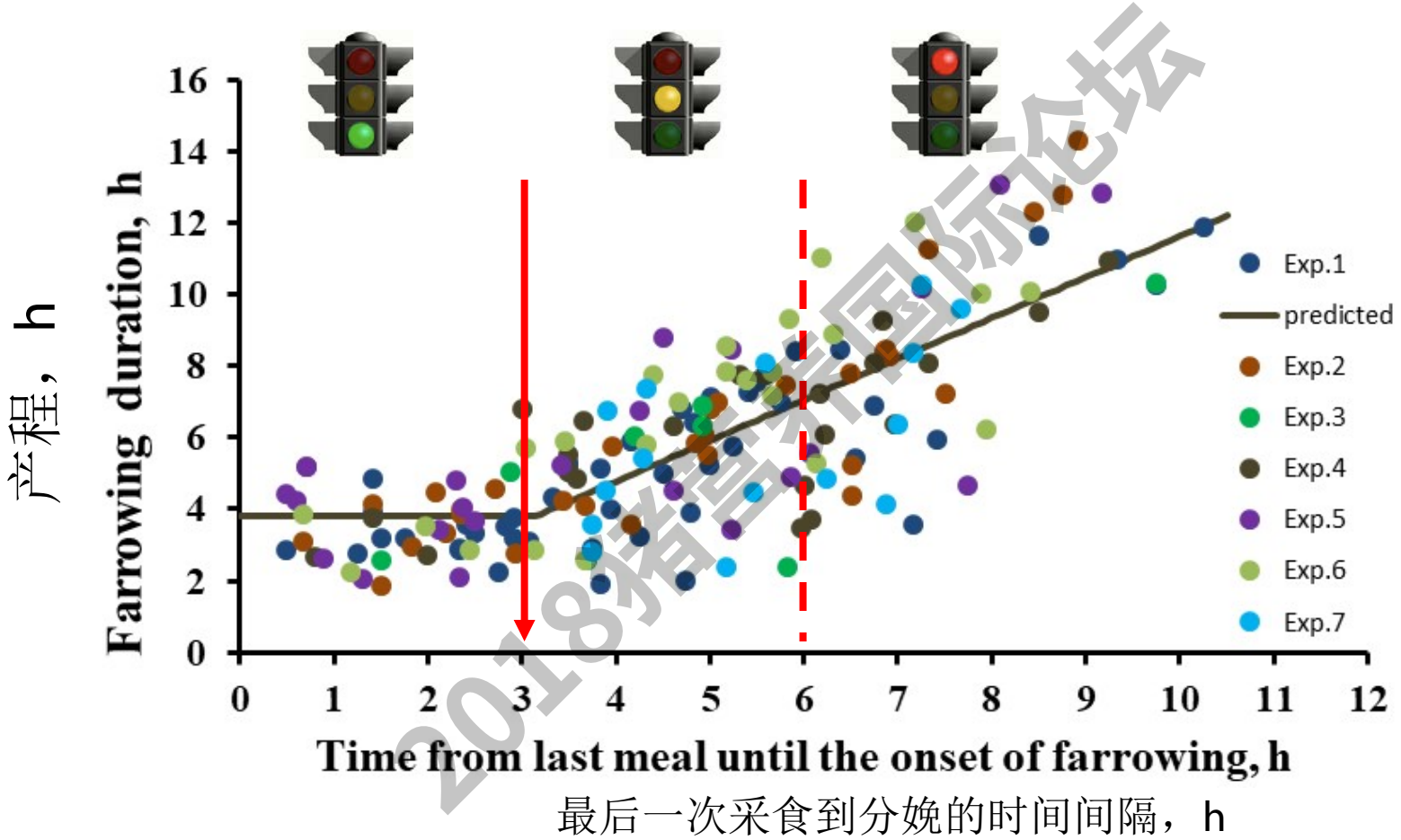
PLASMA GLUCOSE AND FARROWING LENGTH
血浆葡萄糖和产程



Feyera et al. (2018)Feyera等人，2018

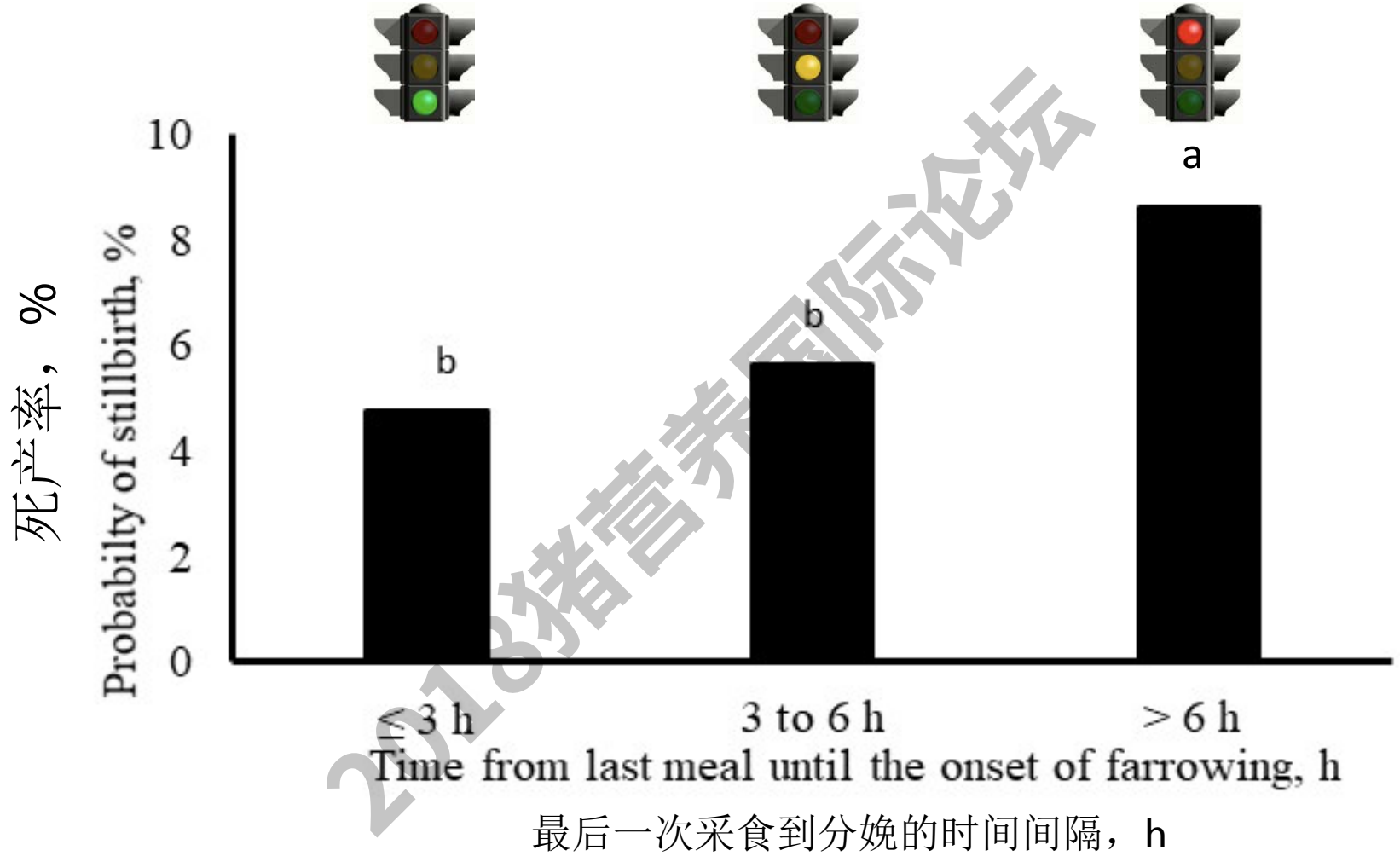
ENERGY STATUS AND FARROWING LENGTH

能量状况与产程



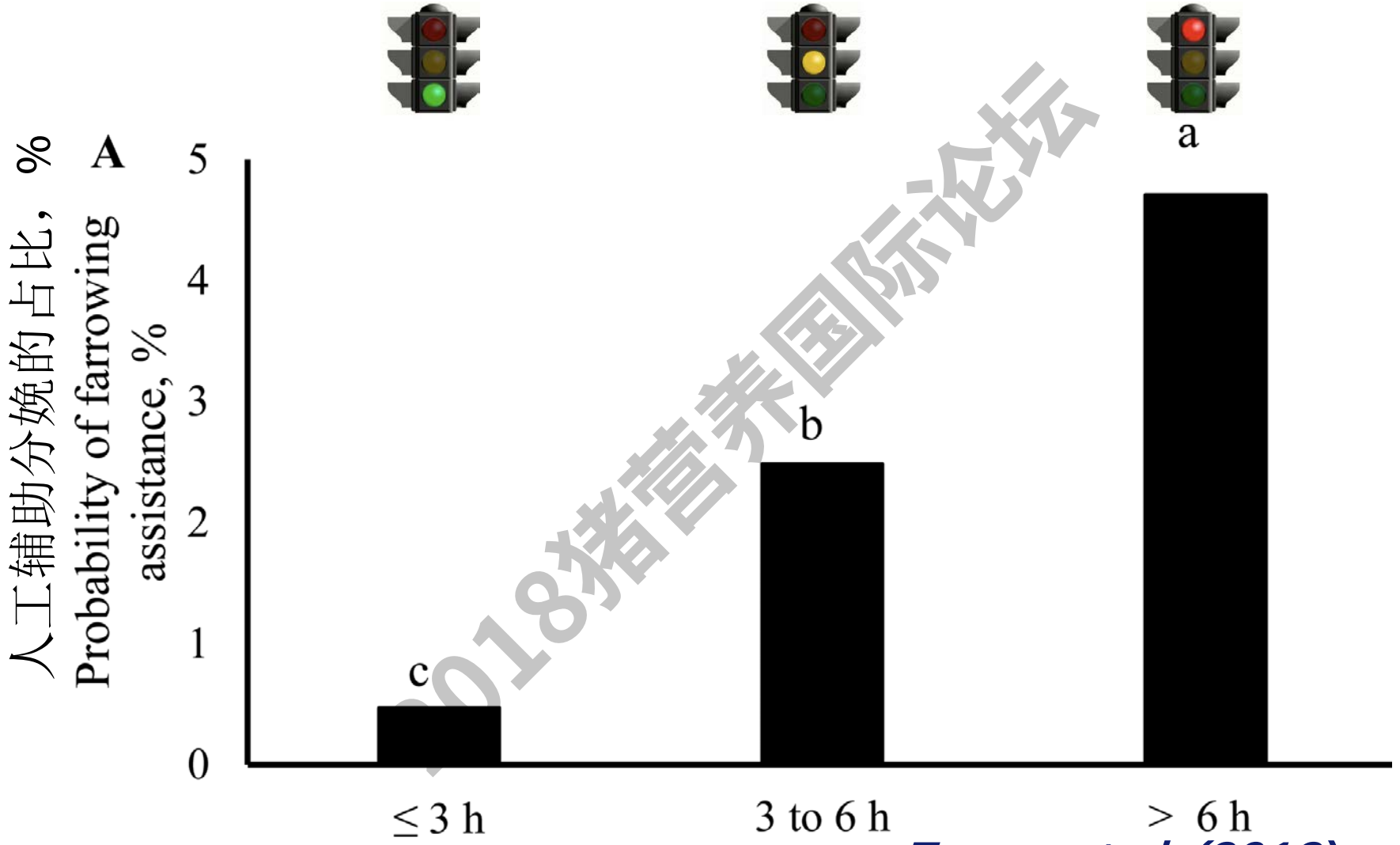
Feyera et al. (2018) *Feyera 等人，2018*

ENERGY STATUS AND STILLBIRTH RATE 能量状态和死产率



Feyera et al. (2018)

ENERGY STATUS AND FARROWING ASSISTANCE
能量状态和人工辅助分娩率



Feyera et al. (2018)

FARROWING IS LIKE RUNNING A MARATHON

ALL PIGLETS MUST BE BORN …

分娩与跑马拉松很像
所有小猪都必需生出来。。。

…..before the plasma glucose level becomes critical low (2 mmol/ L)
。。。在血浆葡糖糖水平还没降到关键水平（2 mmol/ L）之前生出来

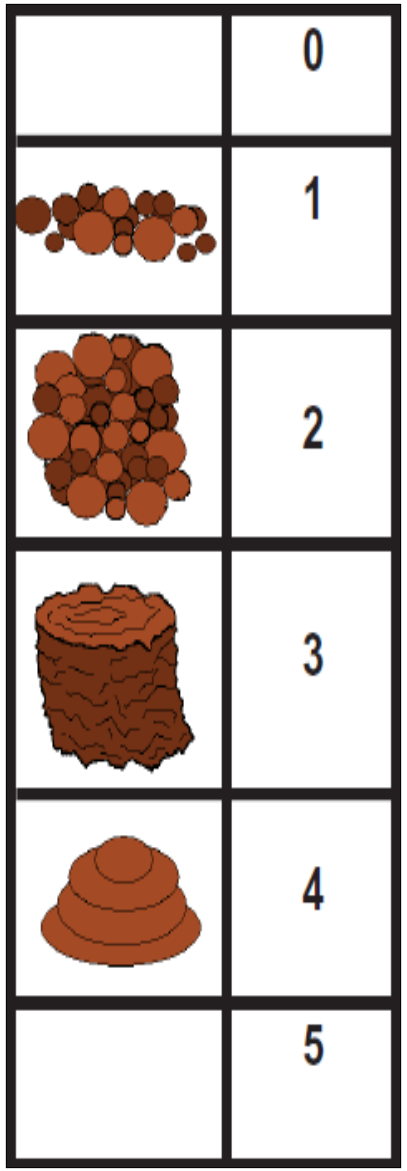
Increased fibre supply and sow productivity

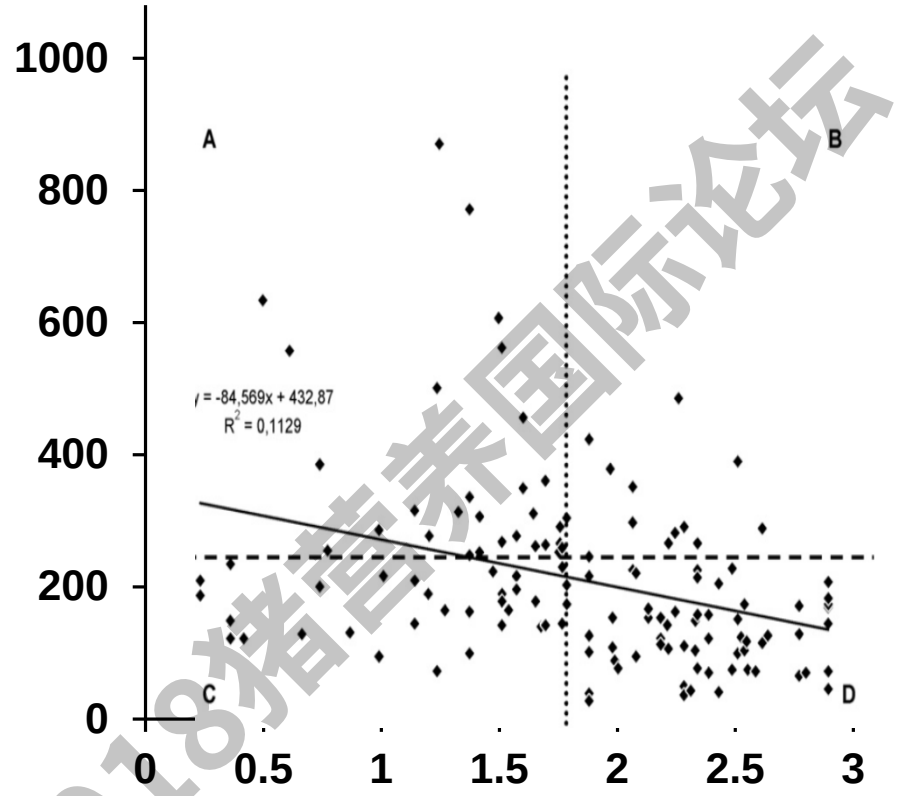
增加纤维供应和母猪生产能力

Control控制	Fiber-suppl.纤维供应	P-valP-缬氨酸
Groups (weeks)组（周）	32	32	
Number of sows 母猪数量	298	322	
Total born per litter每胎产仔数	18.4	18.1	0.38
Dead born per litter, %每胎死亡	8.7	6.6	<0.001
Mortality birth - weaning %断奶前死亡率	14.6	13.7	0.21
Total mortality, %总死亡率%	22.3	19.9	0.004
Medication, %of sows用药母猪的百分比	6.4	5.3	0.66

(Feyera et al., 2017) Feyera等人2017

Constipation and farrowing length便秘和产程





Constipation便秘 soft feces软粪便

(Oliviero et al., 2010 Oliviero等人，2010)

Colostrum and survival初乳与存活

What is most important during the first few critical days?

在最初几天的关键日期最重要的是什么？

1. High colostrum intake (each piglet)

高初乳摄入量（每头小猪）

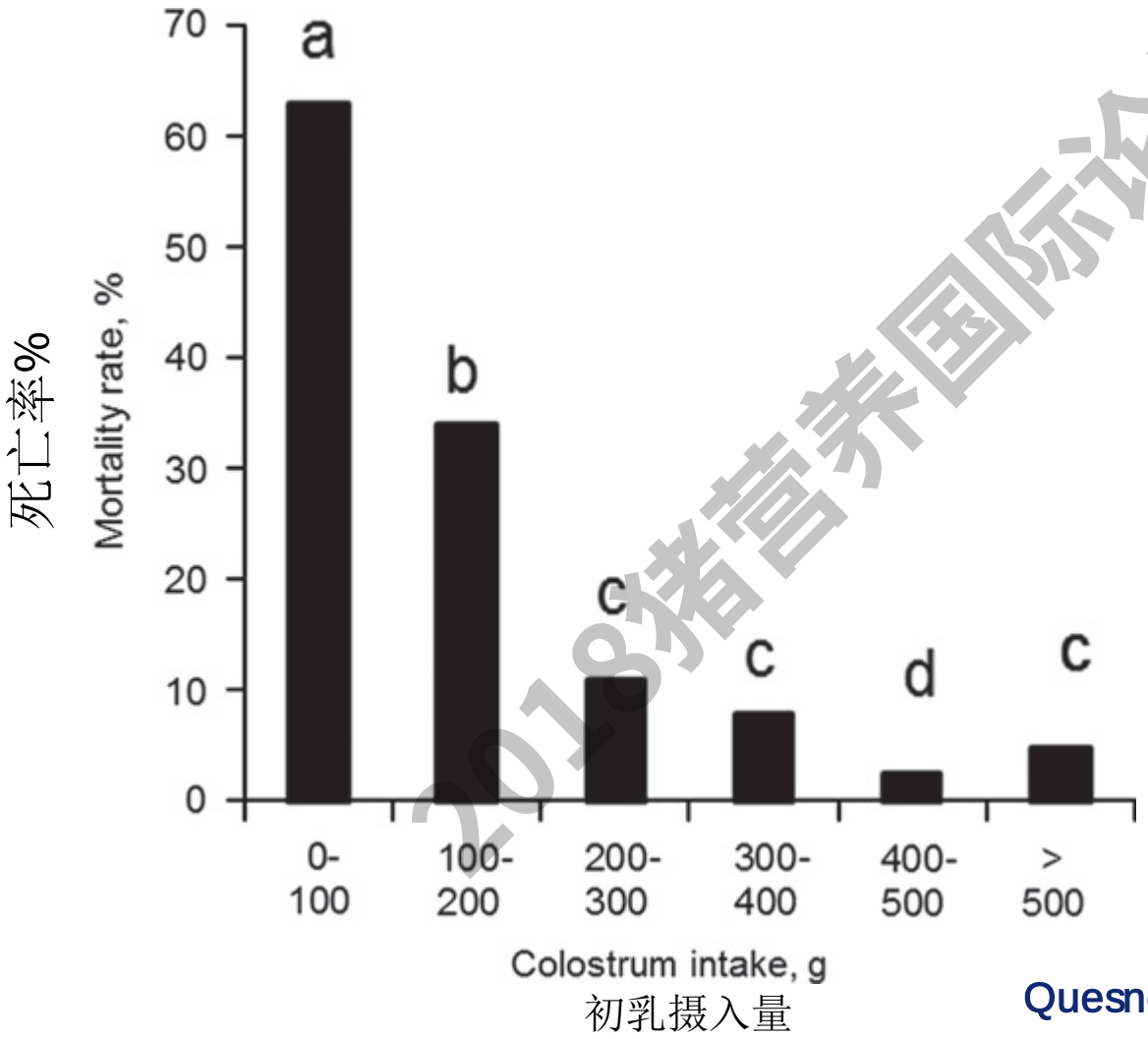
2. High colostrum yield (increases probability of sufficient intake for all littermates)高初乳产量（增加所有仔猪摄入充足初乳的概率）

3. Colostrum quality (Composition, contents of immunoglobulins and growth factors)

初乳质量（免疫球蛋白和生长因子的组成、含量）

Impact of colostrum intake on piglet survival

初乳摄入量对仔猪成活率的影响

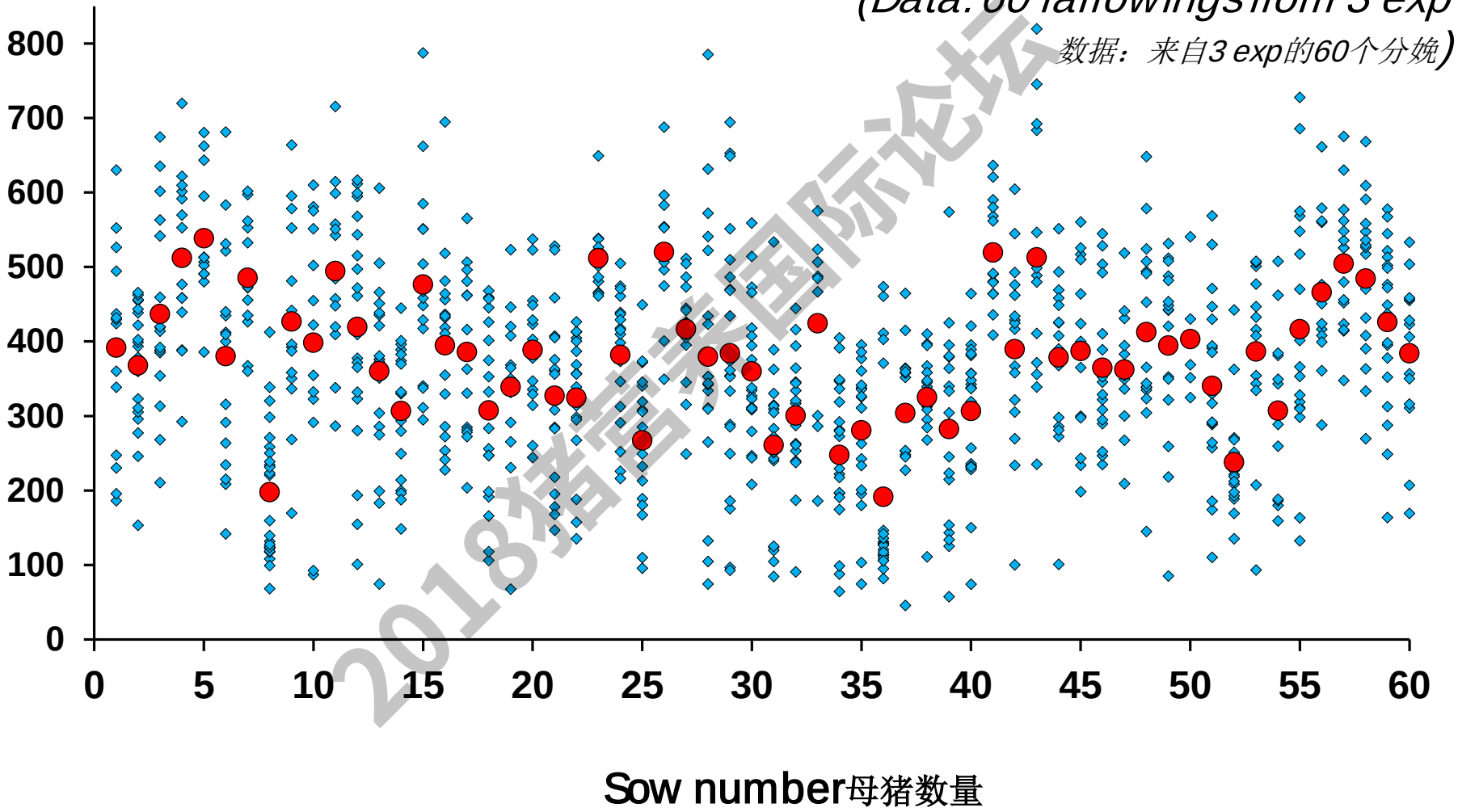


Quesnel et al., (2012) Quesnel等人，2012

Colostrum intake (g/ piglet)初乳摄入量（克/ 仔猪）

(Data: 60 farrowings from 3 exp

数据：来自3 exp的60个分娩)



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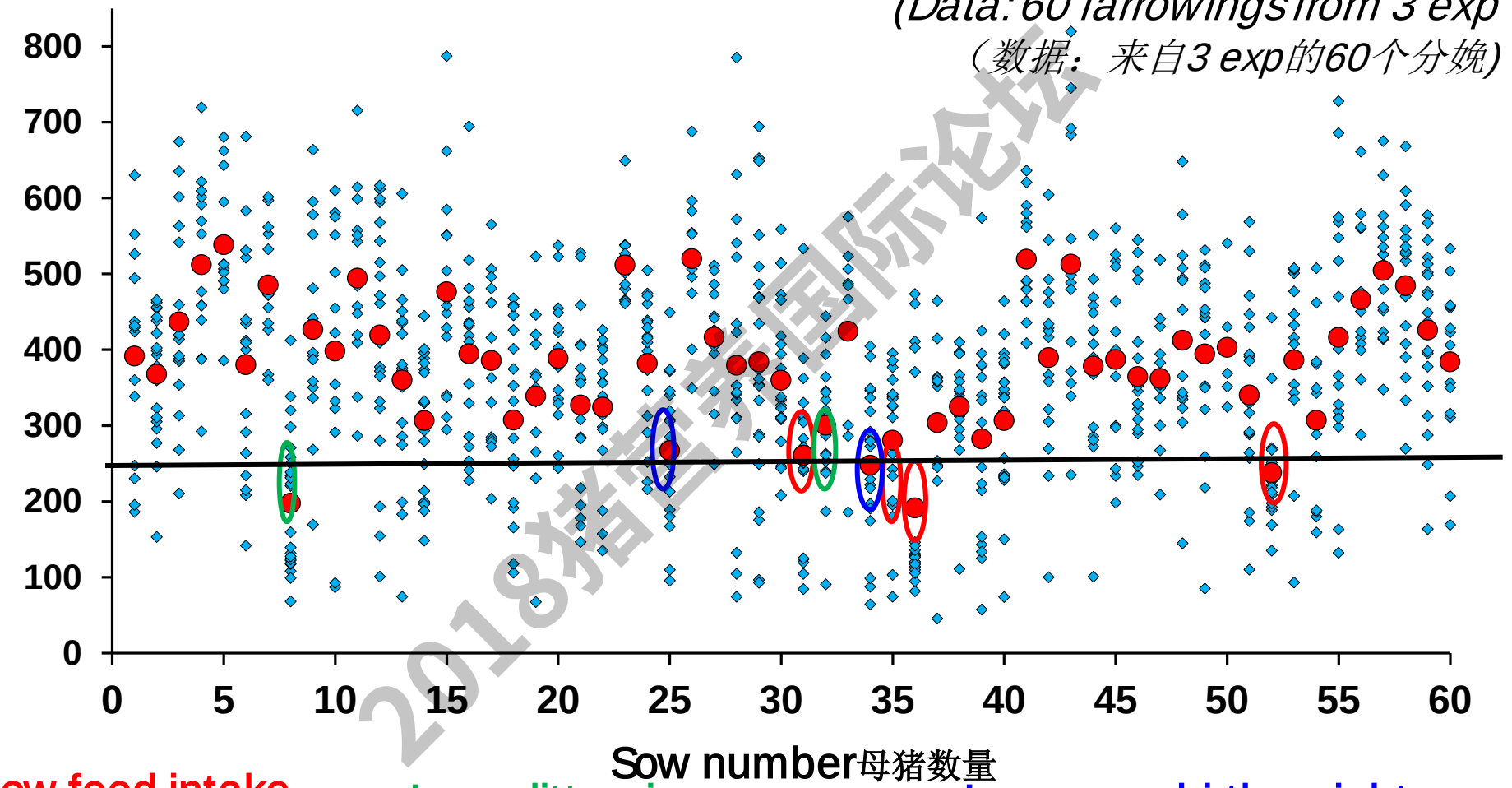


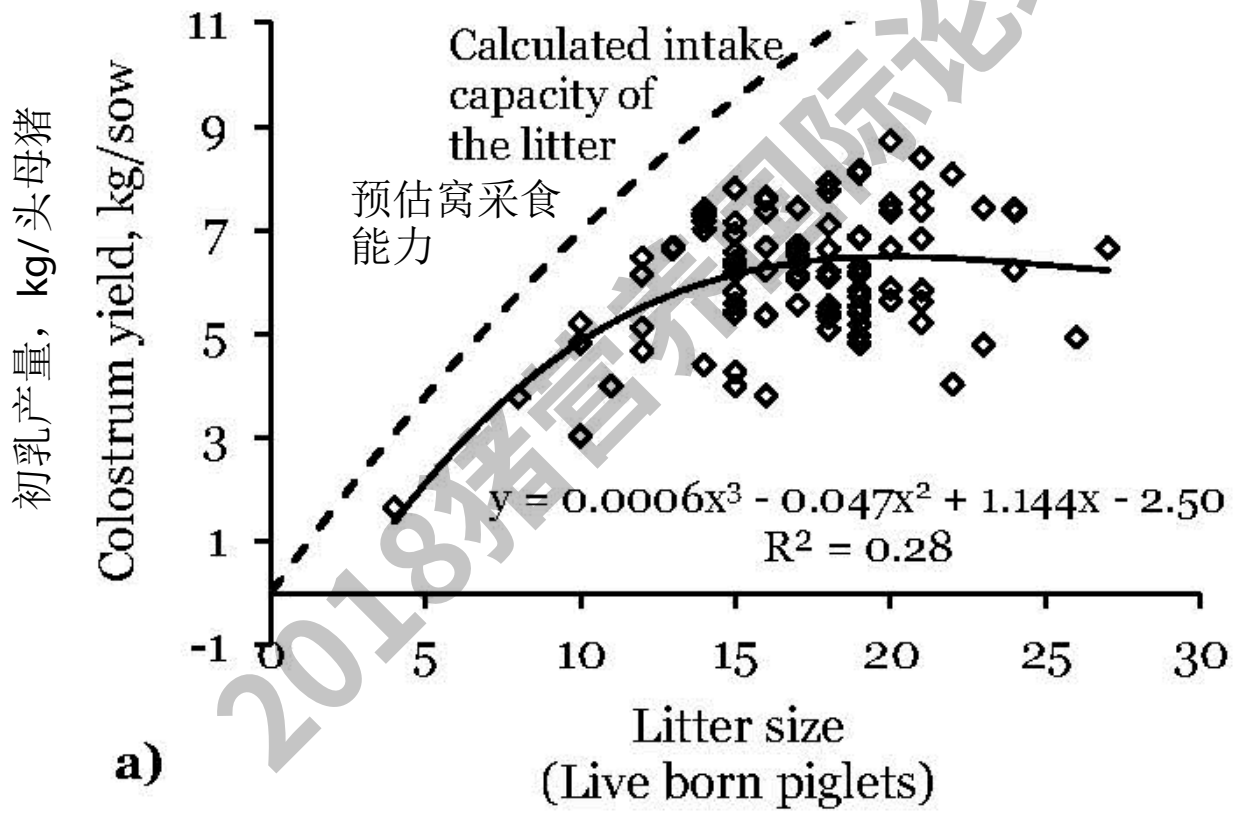
Low feed intake pre partum
产前采食量低

Large litter size (>26)窝产仔数多

Low mean birth weight (average < 900 g)平均出生体重低（平均<900克）

Limiting factor for sow colostrum yield?

母猪初乳产量的限制因素？



Krogh (2017) Krogh2017

Fiber supplementation: which and when? (Theil et al., 2014)纤维补充：种类和何时？ (Theil et al., 2014)

		weight gain (g/ piglet)增重(克/ 仔猪)
33%suger beet pulp 33%甜菜浆	Mating- > d 108 配种->108天	135
21%pectin residue 21%果胶残渣	Mating-> d 108 配种->108天	131
46%potato pulp 46%马铃薯浆	Mating-> d 108 配种->108天	71
Standard gest diet (17%)妊娠日粮(17%)	Mating-> d 108配种->108天	96

(Krogh et al., 2015)

12%suger beet pulp 12%甜菜浆	d 105 -> parturition D 105->分娩	101
17%alfalfa 17％苜蓿	d 105 -> parturition D 105->分娩	90
Standard lact diet (15%)哺乳日粮（15％）	d 105 -> parturition D 105->分娩	85

(Loisel et al., 2013)

SBP, Sunflow, soy (23%DF) 大豆蛋白 (23%DF)	d 106 -> parturition d 106->分娩	76
Low fiber (13%DF)低纤维(13%DF)	d 106 -> parturition d 106->分娩	85

Should fiber in the diets be higher – and when? (Theil et al., 2014)

		weight gain (g/ piglet)	
33% suger beet pulp	Mating- > d 108	135	
21% pectin residue	Mating-> d 108	131	
46% potato pulp	Mating-> d 108	71	
Standard gest diet (17%)	Mating -> d 108	96	

(Kjeldsen et al., 2015)

12% suger beet pulp	d 105 -> parturition	101	
17% alfalfa	d 105 -> parturition	90	
Standard lact diet (15%)	d 105 -> parturition	85	

(Loisel et al., 2013)

SBP, Sunflow, soy (13% DF)	d 106 -> parturition	76	
Low fiber (13% DF)	d 106 -> parturition	85	

Fiber source important!
纤维来源非常重要！

Fiber inclusion level?
纤维添加水平？

Time: Throughout gestation?
使用阶段：整个妊娠期？

Two-component feeding –the way forward?双组份饲喂-未来方向？

maintenance维持

milk production产奶

Energy 能量

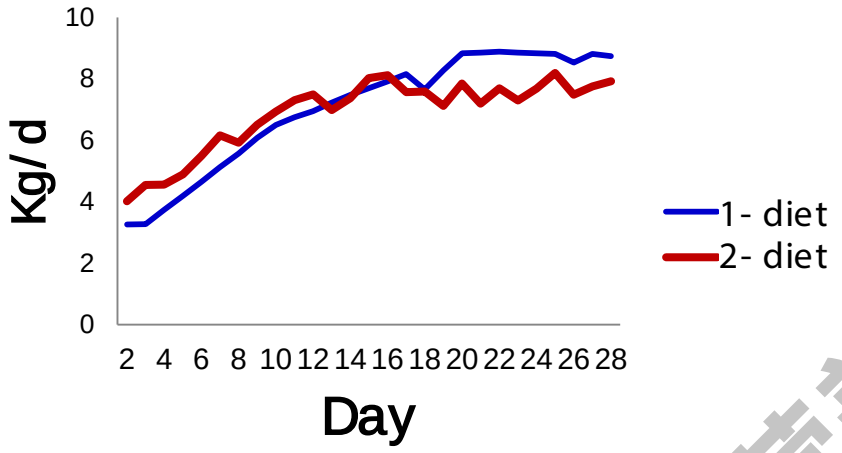
Lysine + energy

赖氨酸+能量

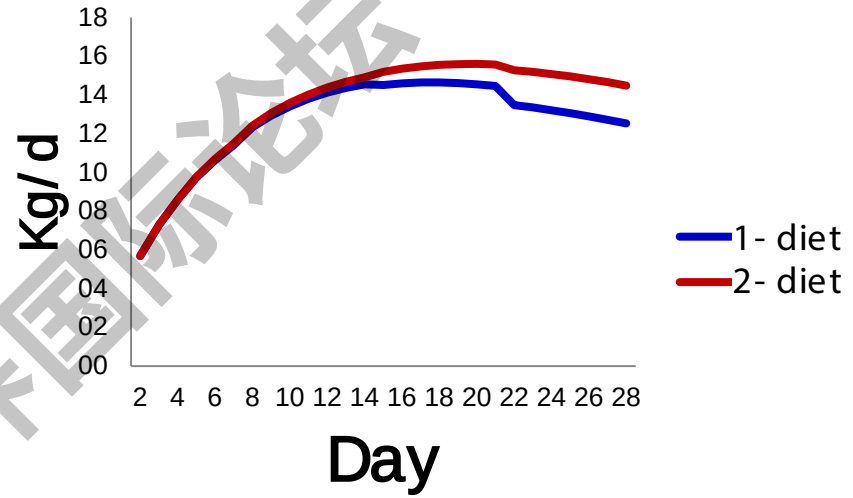
TWO COMPONENT FEEDING双组份喂养

One vs. Two-component feeding 单 vs. 双组份喂养

Feed intake采食量



Milk yield (DIM x TRT; P<0.05) 产奶量（DIM x TRT; P <0.05）



	1-comp	2-comp
Piglet weight at weaning断奶仔猪体重	7.3 kg 7.3公斤	8.0 kg公斤
Sow backfat loss母猪背脂损失	1.8 mm	1.7 mm
Feed intake采食量	6.9 kg/ d 6.9公斤/ 天	6.9 kg/ d 6.9公斤/ 天
Milk yield产奶量	12.5 kg/ d 12.5公斤/ 天	13.3 kg/ d 13.3公斤/ 天

(Pedersen et al., 2016)

2-component feeding trial: Impact of mobilisation双组份喂养试验：动员的影响

	Low Energy低能量		High Energy高能量		
	L-Lys	H-Lys	L-Lys	H-Lys	P-val
Mobilisation动员	Fat+Mus	Fat 脂肪	Muscles肌肉	None无	
SID Lys/ MJ ME	0.53	0.58	0.48	0.53	< 0.01
Sow LW loss母猪体重损失	37[a]	31[a]	21[b]	12[b]	< 0.001
Sow BF loss母猪背膘损失	1.0	1.7	0.1	0.4	0.16
Feed intake采食量	5.4[b]	4.8[b]	7.0[a]	6.9[a]	< 0.001
Milk yield产奶量	13.1[a]	11.6[b]	12.5[a]	12.8[a]	0.05
MY/ kg feed My/ kg 饲料：产奶量	2.4[a]	2.4[a]	1.8[b]	1.9[b]	< 0.001

?

?

Two-component feeding allow:
双组份喂养可以：

⇒ **Targeted feeding day by day**
每日有针对性的喂食

⇒ **Targeted feeding at individual and herd level (litter size)**
以个人和畜群为目标的饲养(产仔数)

⇒ **Targeted feeding according to parity (not only gilts/ multipar)**
按胎次有针对性的喂养(不仅是小母猪/ 多标准)

⇒ **Minimal mobilization from the body**
体组织动员更少

⇒ **High feed efficiency (most milk produced directly from feed)**
饲料效率高（大部分牛奶直接由饲料生产）

Feed饲料 → Growth生长 (+)

Feed intake采食量 +

Optimal Lys/ E-ratio最优Lys/ E比 +

Optimal AA-profile最优AA组成 +

Mobilisation动员

Feed饲料 → Milk yield产奶量

- (Feed饲料 → Mobilisation动员)

+ (Mobilisation动员 → Milk yield产奶量)

+ (Feed饲料 → Milk yield产奶量)

WHY is sow mobilisation and milk yield highly correlated?

为什么母猪动员和产奶量高度相关？

Necessary to reach the potential for milk yield?

是否有必要达到产奶量的潜力？

Consequence of improper feeding?喂食不当的后果？

Feed efficiency:饲料效率：

Growing pigs生长猪: Gain:Feed ratio 肉料比

Lactating sows哺乳母猪: Milk yield:Feed ratio? 产奶量/ 饲料？

NO! Milk produced directly from feed should be maximized by correcting for mobilization

不！需要经过体组成动员量校对后才能最大化饲料直接生产的母乳量

Sow mobilization can be quantified by approaches:母猪动员可通过两种方法加以量化：

1. Body composition –measured by D2O dilution1.体组成 - 通过D2O稀释度测量

⇒ Body pools of protein, fat and minerals can be calculated可以计算蛋白质，脂肪和矿物质

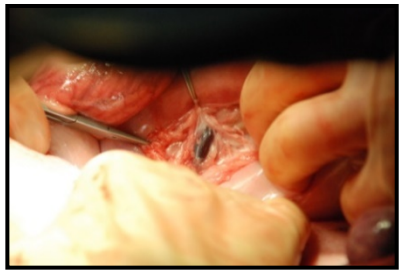
2. Requirement (output) of energy and lysine –calculated factorially

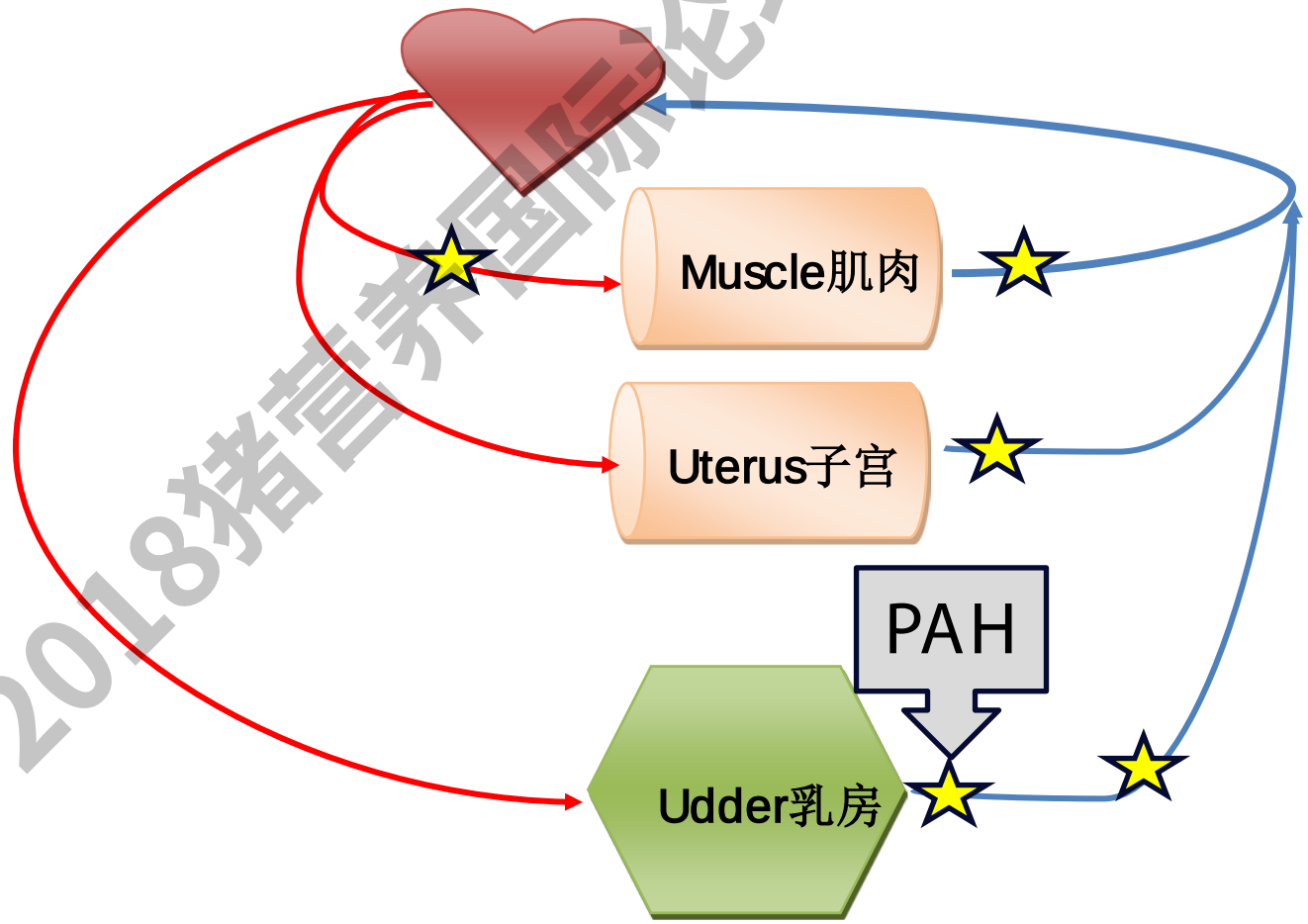
2.能量和赖氨酸的要求（输出） - 按因子计算

⇒ Balances calculates as: Input –output平衡状态通过输入 - 输出计算

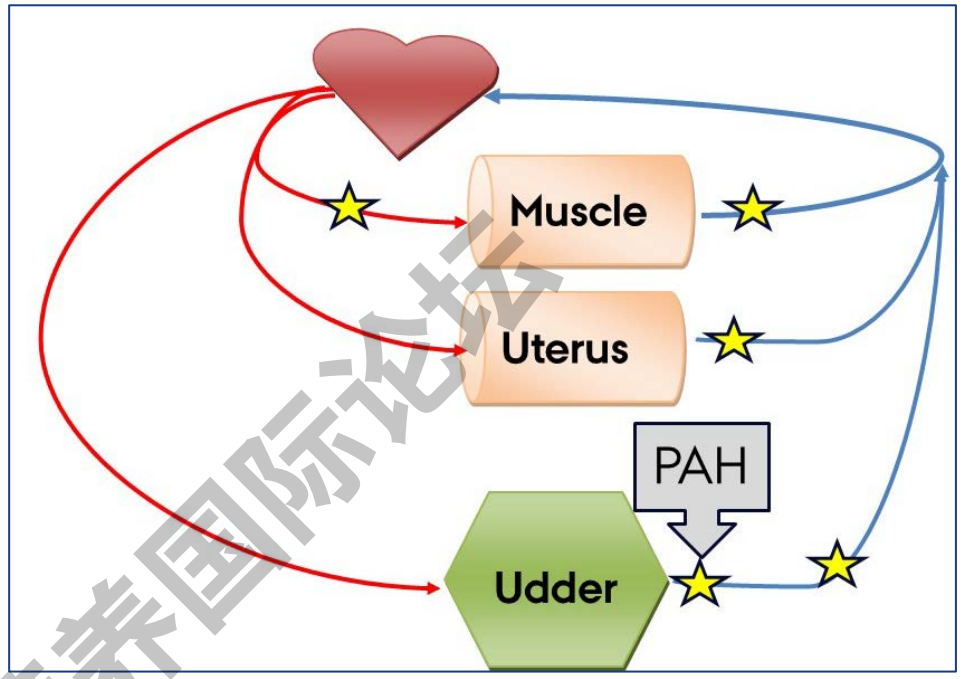
3. AV differences across muscles (indicative of AA mobilization) 3.肌肉间的AV差异（指示AA动员情况）

MULTICATHETERISED SOWS多瘘管母猪



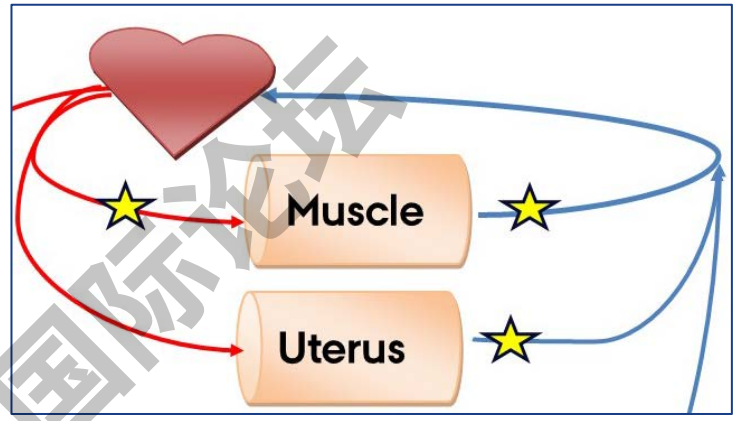


Multicatheterised sows:多瘘管母猪



1. Uterine uptake of energy during farrowing分娩过程中子宫能量的摄取
2. Mammary uptake of energy (carbon) for milk production乳腺摄取能量(碳)生产乳汁
3. Mammary uptake of AA for milk production乳腺摄取AA用于产奶

1. Net uptake of energy to uterus during farrowing 分娩期间子宫的对能量的净摄入



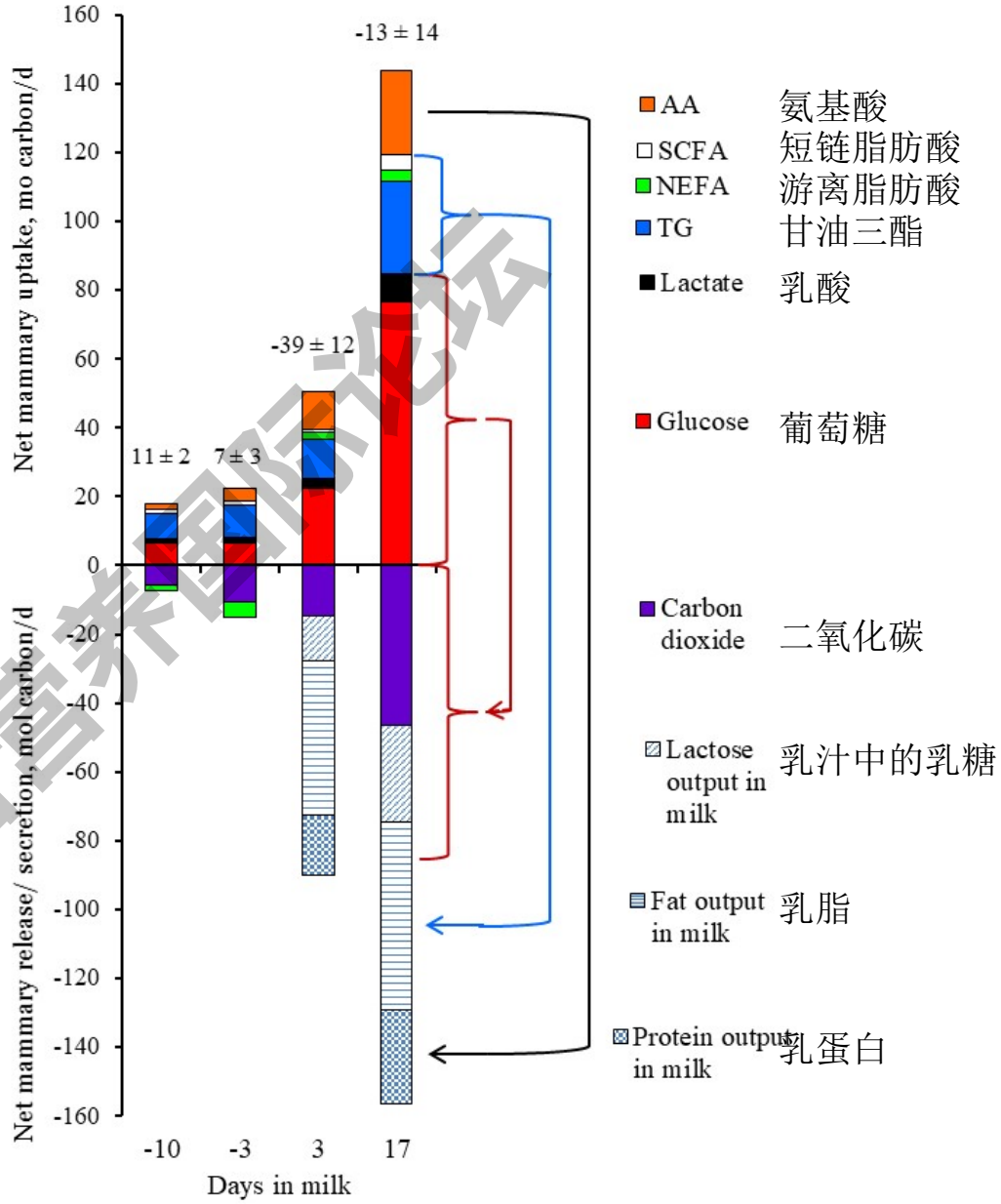
- Glucose葡萄糖（葡糖）
- Triglycerides甘油三酯

BUT NO NET UPTAKE OF:但没有净吸收：

- Short-chain fatty acids短链脂肪酸
- NEFA游离脂肪酸
- Lactate乳酸

2. Mammary uptake of energy (carbon)

2.乳腺能量摄取(碳)



Mammary secretion & mammary release

乳腺分泌物&排出物

3. Mammary extraction of arterial AA's (%)

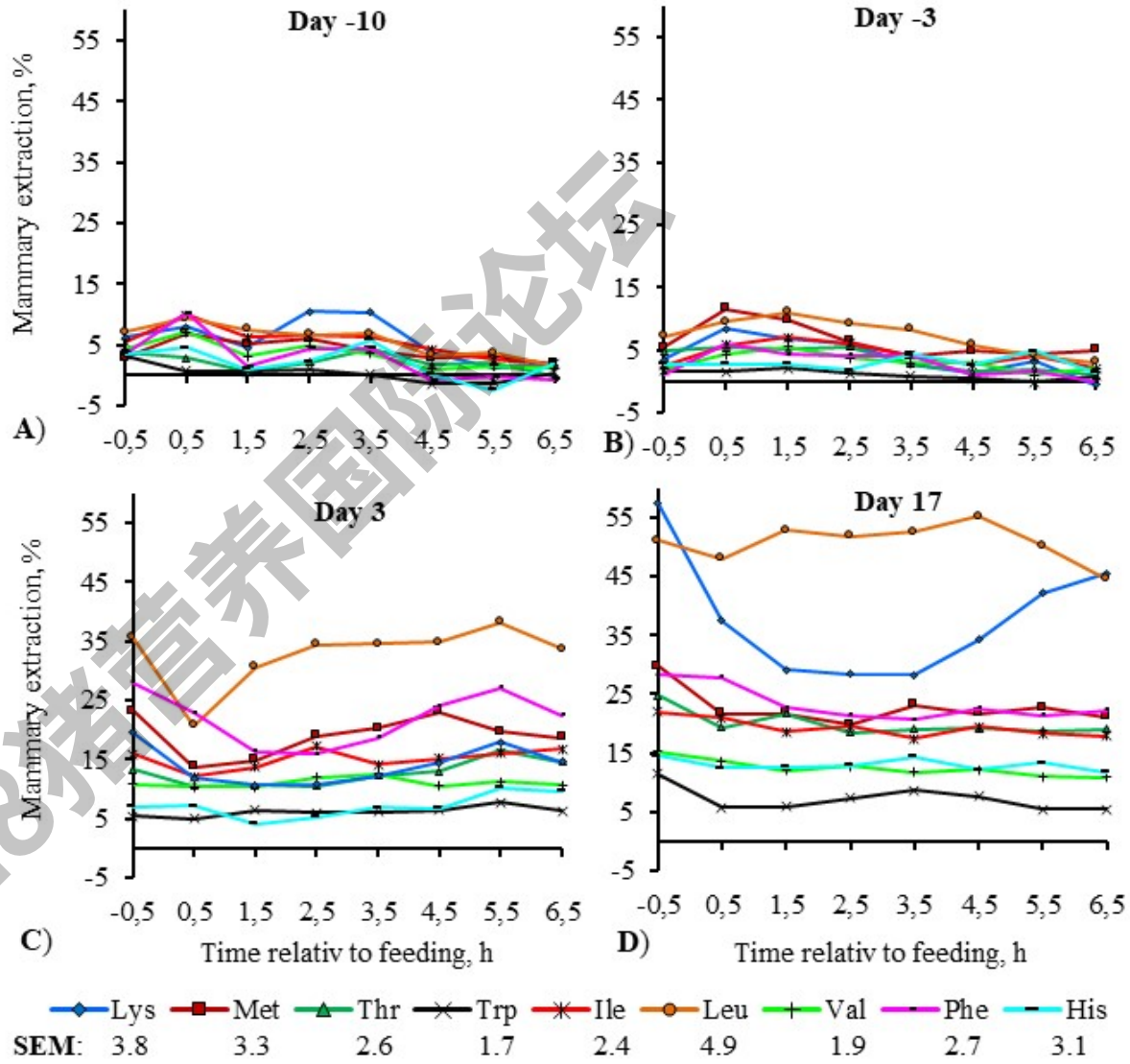
乳腺对动脉AA吸收率(%)

Suggest that AA's are NOT limiting Colostrogenesis

表明AA不限制初乳产量

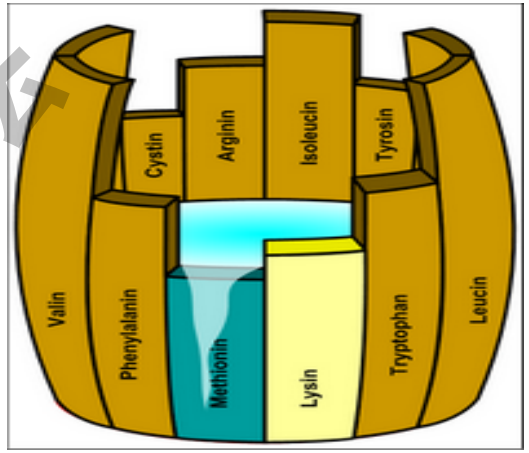
Lysine limited milk yield (confirmed, recommendation was increased after this study by 17%)

赖氨酸限制产奶量(本研究确认可以提高赖氨酸推荐量17%)



Dietary AA supply and milk production: PUSH or PULL?
日粮AA供给和产奶量：供应推动还是需求拉动？

EAA	Art. Blood	Mam. Upt.	Milk牛奶
Lysine赖氨酸	100%	100%	100%
Methionine蛋氨酸	45% ↘	30%	27%
Met + Cys			
Threonine2-氨基-3-羟基丁酸	64% ↘	54%	56%
Isoleucine异亮氨酸	123% ↘	66%	59%
Leucine白氨酸，亮氨酸	79% ↗	109%	115%
Valine缬氨酸	217% ↘	76%	77%
Phenylalanine苯丙氨酸	104% ↘	62%	54%
Phe + Tyr			
Histidine组氨酸	87% ↘	38%	38%

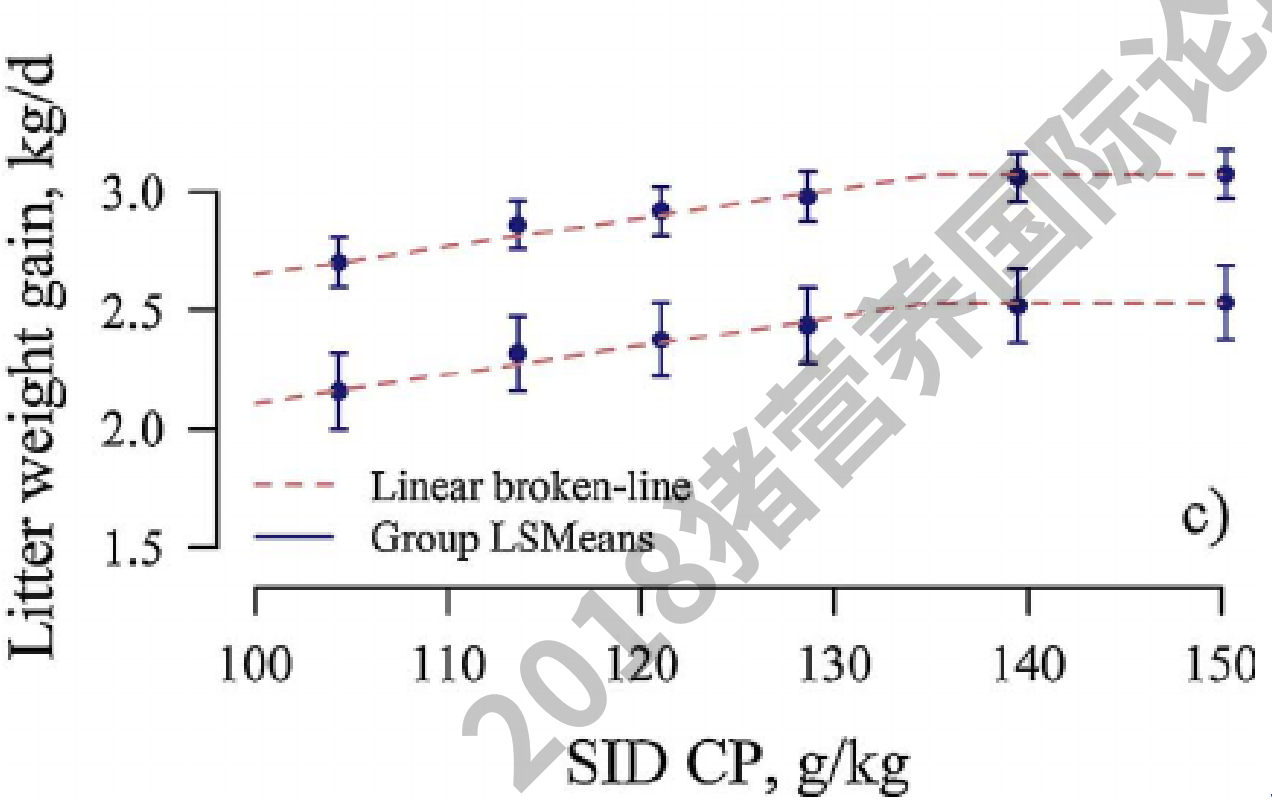


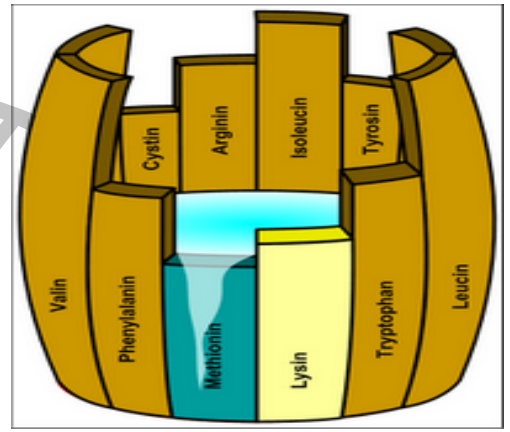
Conclusion:结论:

PULL需求拉动

SID CP requirements of lactating sows

哺乳母猪的SID CP要求





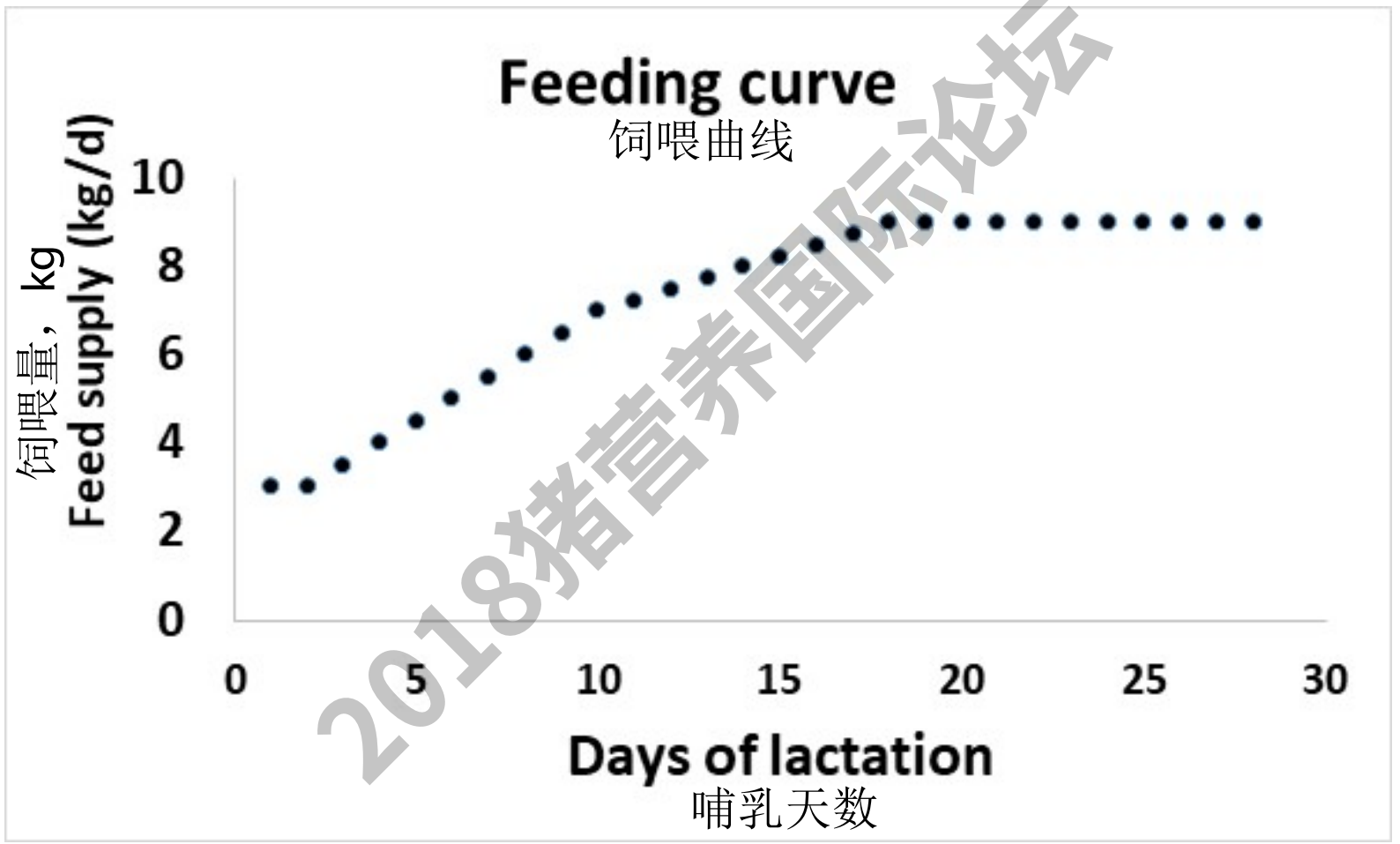
Strathe et al. (2017)

Recommended AA profile for lactation feed哺乳期饲料的推荐AA组成

		SID氨基酸，g/饲料单位	占赖氨酸比
		G SID per feed unit	% of lysine
赖氨酸	Lysine	7.7	100
蛋氨酸	Methionine	2.4	31
蛋+胱	Methionine + cysteine	4.5	58
苏氨酸	Threonine	5.0	65
色氨酸	Tryptophan	1.54	20
异亮氨酸	Isoleucine	4.3	56
亮氨酸	Leucine	8.3	108
组氨酸	Histidine	2.8	36
苯丙氨酸	Phenylalanine	4.2	55
苯丙+酪	Phenylalanine+Tyrosine	8.7	113
缬氨酸	Valine	5.3	69
SID粗蛋白	Crude protein (SID)	118	-

1 Danish feed unit is ~ 0.94 kg in lactation feed 1丹麦饲料单位为0.94千克哺乳饲料

Recommended feeding in practice推荐实际饲喂量



Conclusions结论

- Sows lack energy during farrowing - more daily meals needed 母猪在分娩时缺乏能量–每日需要更多膳食
- Fiber in feed: constipation ↓ Energy status ↑ stillbirth rate ↓ 饲料中的纤维：减少便秘，改善能量状态，降低死产率
- Colostrum is HIGHLY important for piglet survival 初乳对仔猪的生存至关重要
- Some fibers (sugar beet pulp or pectin) enhance colostrum yield 一些纤维（甜菜浆或果胶）增加初乳产量
- Multicatheterized sows improve our understanding GREATLY 多瘘管母猪极大地提高了我们的理解
- Feed intake and mobilization needs to be integrated to understand feed efficiency of lactating sows 需要整合采食量和动员以了解泌乳母猪的饲料效率
- Two component feeding (uncoupled supply of energy and AA) is a promising approach to increase milk yield/ reduce mobil.双组分饲喂（能量和AA的非耦合供应）是增加产奶量/ 减少体损失的有效方法。

Thank you for your attention ☺谢谢大家☺